Corrosion and Corrosion Control in LWRs
Glossary*

A

Acid: a substance which releases hydrogen ions when dissolved in water and will react with a base to form a neutral salt and water. (see pH)

Activation overpotential: the overpotential associated with the charge-transfer reaction elementary step in the overall electrode reaction

Active: the negative direction of electrode potential (Also used to describe corrosion and its associated potential range when an electrode potential is more negative than an adjacent depressed corrosion rate [passive] range.

Activity: a measure of the chemical potential of a substance, where chemical potential is not equal to concentration, that allows mathematical relations equivalent to those for ideal systems to be used to correlate changes in an experimentally measured quantity with changes in chemical potential.

Activity (ion): the ion concentration corrected for deviations from ideal behavior. Concentration multiplied by activity coefficient.

Activity coefficient: a characteristic of a quantity expressing the deviation of a solution from ideal thermodynamic behavior; often used in connection with electrolytes.

Adsorb: to take in on the surface.

Aeration cell: an oxygen concentration cell; an electrolytic cell resulting from differences in dissolved oxygen at two points. Also see differential aeration cell.

Alkaline: a) Having properties of an alkali and b) having a pH greater than 7.

Anion: a negatively charged ion.

Anode: the electrode of an electrolytic cell at which oxidation is the principal reaction. (Electrons flow away from the anode in the external circuit. It is usually the electrode where corrosion occurs and metal ions enter solution.

Anodic polarization: the change of the electrode potential in the noble (positive) direction due to current flow (See polarization).

Anodic protection: a technique to reduce corrosion of a metal surface under some conditions by passing sufficient to it to cause its electrode potential to enter and remain in the passive region; imposing an external electrical potential to protect a metal from corrosive attack. (Applicable only to metals that show active-passive behavior.) Contrast with cathodic protection.

* Most definitions are complements of Corrosion Doctors www.corrosion-doctors.org

Anolyte: the electrolyte adjacent to the anode of an electrolytic cell.
Aqueous: pertaining to water; an aqueous solution is made by using water as a solvent.

Atmospheric corrosion: the gradual degradation or alteration of a material by contact with substances present in the atmosphere, such as oxygen, carbon dioxide, water vapor, and sulfur and chlorine compounds.

Atom: the smallest particle of an element that can exist either alone or in combination.

Auxiliary electrode: the electrode in an electrochemical cell that is used to transfer current to or from a test electrode, usually made of non-corroding material.

B

Backfill: material placed in a drilled hole to fill space around anodes, vent pipe, and buried components of a cathodic protection system.

Base: a substance that releases hydroxyl ions when dissolved in water. Bases react with acids to form a neutral salt and water.

Beach marks: macroscopic progression marks on a fatigue fracture or stress-corrosion cracking surface that indicate successive positions of the advancing crack front. The classic appearance is of irregular elliptical or semielliptical rings, radiating outward from one or more origins. See also striation.

Boric acid corrosion (BAC): Corrosion of carbon steel and low alloy steel due to leaks of PWR primary coolant.

C

Cathode: the electrode of an electrolytic cell at which reduction is the principal reaction. Electrons flow toward the cathode in the external circuit.

Cathodic polarization: the change of the electrode potential in the active (negative) direction due to current flow. (See polarization).

Cathodic protection (CP): a corrosion control system in which the metal to be protected is made to serve as a cathode, either by the deliberate establishment of a galvanic cell or by impressed current. (see anode.)

Cathodic reaction: electrode reaction equivalent to a transfer of negative charge from the electronic to the ionic conductor. A cathodic reaction is a reduction process.

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Catholyte: the electrolyte adjacent to the cathode of an electrolytic cell.

Cation: a positively charged ion.

Caustic cracking: stress corrosion cracking of metals in caustic solutions. (See also stress corrosion cracking).

Cavitation: the formation and rapid collapse within a liquid of cavities or bubbles that contain vapor or gas or both.

Cavitation-erosion: progressive loss of original material from a solid surface due to continuing exposure to cavitation.

Constant extension rate testing (CERT): an experimental technique for evaluating susceptibility to stress corrosion cracking. It involves pulling the specimen to failure in uniaxial tension at a controlled slow strain rate while the specimen is in the test environment and examining the specimen for evidence of stress corrosion cracking. Same as SSRT.

Chemical potential: in a thermodynamic system of several constituents, the rate of change of the Gibbs function of the system with respect to the change in the number of moles of a particular constituent.

Chlorides: salts of chloride are generally soluble. High concentrations contribute to corrosion problems.

Concentration cell: an electrolytic cell, the emf of which is caused by a difference in concentration of some component in the electrolyte. (This difference leads to the formation of discrete cathode and anode regions).

Concentration polarization: that portion of the polarization of a cell produced by concentration changes resulting from passage of' current through the electrolyte.

Conductivity: the property of a water or soil sample to transmit electric current (inverse of resistivity) under a set of standard conditions. Usually expressed as μS/cm. (S = Siemens)

Corrosion: the electrochemical reaction between a material, usually a metal, and its environment that produces a deterioration of the material and/or its properties.

Corrosion fatigue: the process in which a metal fractures prematurely under conditions of simultaneous corrosion and repeated cyclic loading at lower stress levels or fewer cycles than would be required in the absence of the corrosive environment.

Corrosion potential: the potential of a corroding surface in an electrolyte relative to a reference electrode measured under open-circuit conditions.

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Corrosion product: substance formed as a result of corrosion.

Corrosion rate: the amount of corrosion occurring in unit time. (For example, mass change per unit area per unit time; penetration per unit time).

Corrosion resistance: ability of a metal to withstand corrosion in a given corrosion system.

Counter electrode: See auxiliary electrode.

Current density: the electric current to or from a unit area of an electrode surface. (Not today's stupidity.)\

Crevice corrosion: corrosion of a metal surface at, or immediately adjacent to, an area that is shielded from full exposure to the environment because of close proximity between the metal and the surface of another material.

Crud-induced localized corrosion (CILC): accelerated corrosion of zircaloy fuel in BWR environments due the deposit of crud on the fuel

D

Dealloying: preferential dissolution of an alloying element due to corrosion (aka parting corrosion or selective leaching).

Degree of sensitization (DOS): amount of chromium carbides precipitated at the grain boundaries. (see EPR).

Denickelification: corrosion in which nickel is selectively dissolved from nickel-containing alloys. Most commonly observed in copper-nickel alloys after extended service in fresh water.

Dezincification: corrosion in which zinc is selectively dissolved from zinc-containing alloys. Most commonly found in copper-zinc alloys containing less than 83% copper after extended service in water containing dissolved oxygen; the parting of zinc from an alloy (in some brasses, zinc is lost leaving a weak, brittle, porous, copper rich residue behind).

Differential aeration cell: An electrolytic cell, the electromotive force of which is due to a difference in air (oxygen) concentration at one electrode as compared with that at another electrode of the same material; an oxygen concentration cell (a cell resulting from a potential difference caused by different amounts of oxygen dissolved at two locations). See also concentration cell

Double layer: the interface between an electrode or a suspended particle and an electrolyte created by charge-charge interaction (charge separation) leading to an alignment of oppositely charged ions at the surface of the electrode or particle.

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E

Electrochemical cell: an electrochemical system consisting of an anode and a cathode in metallic contact and immersed in an electrolyte. (The anode and cathode may be different metals or dissimilar areas on the same metal surface).

Electrochemical potentiokinetic reactivation (EPR): Quantitative technique to measure the degree of sensitization of austenitic stainless steel.

Electrode potential: the potential of an electrode in an electrolyte as measured against a reference electrode. (The electrode potential does not include any resistance losses in potential in either the solution or external circuit. It represents the reversible work to move a unit charge from the electrode surface through the solution to the reference electrode).

Electrolyte: a nonmetallic substance that carries an electric current, or a substance which, when dissolved in water, separates into ions which can carry an electric current.

Electrolytic cell: an assembly, consisting of a vessel, electrodes, and an electrolyte, in which electrolysis can be carried out.

Electromotive force series (emf series): a list of elements arranged according to their standard electrode potentials, with "noble" metals such as gold being positive and "active" metals such as zinc being negative.

Electron: a fundamental particle found in the atom that carries a single negative charge.

Electron volt: unit equal to the energy of one electron moving through a potential difference of one volt.

Environmentally assisted cracking (EAC): cracking of a ductile material in which the corrosive effect of the environment is a causative factor. EAC is a general term that includes corrosion fatigue and stress corrosion cracking (SCC).

Equilibrium: the state in which the action of multiple forces produce a stead balance.

Equivalent weight: the weight in grams of an element, compound or ion which would react with or replace 1 gram of hydrogen; the molecular weight in grams divided by the valence.
Erosion: the progressive loss of material from a solid surface due to mechanical interaction between that surface and a fluid, a multi-component fluid, or solid particles carried with the fluid.

Erosion-corrosion: a conjoint action involving corrosion and erosion in the presence of a moving corrosive fluid leading to the accelerated loss of material.

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Evans diagram: Electrode kinetic data are typically presented in a graphical form called Evans diagrams, polarization diagrams or mixed potential diagrams. Any electrochemical reaction can be algebraically divided into separate oxidation and reduction reactions with no net accumulation of electrical charge with these diagrams.

Exchange current density: the rate of charge transfer per unit area when an electrode reaches dynamic equilibrium (at its reversible potential) in a solution: that is the rate of anodic charge transfer (oxidation) balances the rate of cathodic charge transfer (reduction).

Exfoliation: corrosion that proceeds laterally from the sites of initiation along planes parallel to the surface, generally at grain boundaries, forming corrosion products that force metal away from the body of the material giving rise to a layered appearance.

F

Faraday constant: Named after Michael Faraday) is the magnitude of electric charge per mole of electrons, i.e., 23.061 kcal per volt gram equivalent or 96.485 kJ per volt gram equivalent.

Film: a thin, not necessarily visible, layer of material.

Flow-accelerated corrosion (FAC): term developed by Electric Power Research Institute (EPRI) to describe the single phase erosion corrosion (EC) of carbon steel in LWRs.

Fretting corrosion: the deterioration at the interface between contacting surfaces as the result of corrosion and slight oscillatory slip between the two surfaces.

G

Galvanizing: the process by which steel is coated with a layer of zinc. The zinc coating provides the steel with greater corrosion resistance.

Galvanic cell: a cell which generates an electrical current, consisting of dissimilar metals in contact with each other and with an electrolyte or the same metal in contact with dissimilar electrolytes.

Galvanic corrosion: accelerated corrosion of a metal because of an electrical contact with a more noble metal or a different electrolyte/environment.

Galvanic couple: a pair of dissimilar conductors commonly metals in electrical contact. (See galvanic corrosion).

Galvanic current: the electric current between metals or conductive nonmetals in a galvanic couple.

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Galvanic Series: a list of metals and allots arranged according to their relative corrosion potentials in a given environment.

Galvanizing: to coat a metal surface with zinc using any of various processes.

General corrosion: a form of deterioration that is distributed more or less uniformly over a surface; see uniform corrosion.

Gibbs free energy: thermodynamic function also called free energy, free enthalpy, or gibbs function.

Grain boundary attack: same as intergranular attack (IGA)

Graphitic corrosion: a form of Dealloying corrosion specific to the deterioration of metallic constituents in gray cast iron, which leaves the graphitic particles intact.

H

Helmholtz Double Layer: When a metal dissolves continuously, it may become increasingly negatively charged because of passage of continuous positive ions in the solution. The excess negative charge on the metal surface balances the excess positive charge and the solution side of the interface and hence, a separation of charges exists.

The electrons orient themselves opposite a layer of cations of equal and opposite charges on the solution side of the interface. The electric field which is created consists of two layers of charges; hence it has been given a name double layer. The separation of charges in the double layer can be compared to parallel plates in a capacitor as it was done by Helmholtz. The double layer is also called Helmholtz Double Layer.

Huey test: corrosion testing in a boiling solution of nitric acid. This test is mainly used to detect the susceptibility to intergranular corrosion of stainless steel due to the precipitation of chromium carbides at the grain boundaries.

Hydroxide: a chemical compound containing hydroxyl ion. (see pH)

Hydroxyl: the OH^- anion that has a single negative charge and provides the characteristics common to bases. (see pH)

I

Impingement corrosion: a form of erosion-corrosion generally associated with the local impingement of a high-velocity, flowing fluid against a solid surface.

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Impressed current: an electric current supplied by a device employing a power source that is external to the electrode system. (An example is dc current for cathodic protection).

Incubation period: a period prior to the detection of corrosion while the metal is in contact with a corrosive environment.

Inhibitor: a chemical substance or combination of substances that, when present in the proper concentration and forms in the environment, prevents or reduces corrosion.

Intergranular: between grains.

Intergranular attack (IGA): preferential corrosion at or adjacent to the grain boundaries of a metal or alloy.

Interdendritic stress corrosion cracking (IDSCC): stress corrosion cracking (SCC) that propagates interdendriticly through the dendrites of cast or weld metal.

Intergranular stress corrosion cracking (IGSCC): stress corrosion cracking (SCC) that propagates intergranularly. (see stress corrosion cracking)

Intragranular: British term for through the grains, i.e., transgranular.

Ion: an atom, or group of atoms, that has gained or lost one or more outer electrons and thus carries an electric charge. Positive ions, or cations, are deficient in outer electrons. Negative ions, or anions, have an excess of outer electrons.

Irradiation assisted stress corrosion cracking (IASCC): IGSCC of alloys in LWR environments due to the simultaneous interaction of an irradiated microstructure (e.g., high dislocation density, voids), environment and tensile stress.

Knifeline attack (KLA): intergranular corrosion of an alloy, usually stabilized austenitic stainless steel (e.g., Type 321, 347 stainless steel), along a line adjoining or in contact with a weld after heating into the sensitization temperature range.

L

Local cell: a galvanic cell resulting from inhomogeneities between areas on a metal surface in an electrolyte. The inhomogeneities may be of physical or chemical nature in either the metal or its environment.

Low potential stress corrosion cracking (LPSCC): IGSCC of LWR alloys under low corrosion potential conditions. Often limited to as IGSCC of stainless steels in PWRs.

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M

Microbiologically Influenced Corrosion (MIC): sometimes called microbial corrosion or bio corrosion refers to corrosion that is affected by the action of microorganisms in the environment.

Mixed potential: the potential of a specimen (or specimens in a galvanic couple) when two or more electrochemical reactions are occurring simultaneously.

N

Negative charge: the electrical charge on an electrode or ion in solution, due to the presence of an excess of electrons. (See electron, anion.)

Nernst equation: describes the fundamental relationship between the potential applied to an electrode and the concentration of the redox species at the electrode surface.1 If an electrode is at equilibrium with the solution in which it is immersed, the electrode will have a potential, invariant with time, which is thermodynamically related to the composition of the solution.

Noble: the positive (increasingly oxidizing) direction of electrode potential.

Noble metal: a metal with a standard electrode potential that is more noble (positive) than that of hydrogen.

Noble potential: a potential more cathodic (positive) than the standard hydrogen potential.

O

Occluded cell: an electrochemical cell created at a localized site on a metal surface that has been partially obstructed from the bulk environment.

Open-circuit potential: the potential of an electrode measured with respect to a reference electrode or another electrode when no current flows to or from it.

Overpotential: is the potential (voltage) difference between a half-reaction's thermodynamically determined reduction potential and the potential at which the redox event is experimentally observed.

Oxidation: loss of electrons by a constituent of a chemical reaction. (Not a primitive farming technique.)

Oxygen concentration cell: a galvanic cell resulting from difference in oxygen concentration between two locations; see differential aeration cell.

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P

Parting corrosion: a British term for dealloying corrosion.

Parts per billion (ppb): a measure of proportion by weight, equivalent to one unit weight of a material per billion (10^9) unit weights of compound. One ppb is equivalent to 1 µg/l or 1 µg/kg.

Parts per million (ppm): a measure of proportion by weight, equivalent to one unit weight of a material per million (10^6) unit weights of compound. One ppm is equivalent to 1 mg/l or 1 mg/kg.

Passivation: the process in metal corrosion by which metals become passive. (See passive).

Passive: the state of the metal surface characterized by low corrosion rates in a potential region that is strongly oxidizing for the metal.

Passivity: a condition in which a piece of metal, because of an impervious covering of oxide or other compound, has a potential much more positive than that at the metal in the active state.

pH: "power of hydrogen," a measure of the acidity or alkalinity of a solution; the negative logarithm of the hydrogen-ion activity; it denotes the degree of acidity or basicity of a solution at 25ºC, 7.0 is the neutral value. Decreasing values below 7.0 indicate increasing acidity; increasing values above 7.0, increasing basicity.

Pitting: corrosion of an open metal surface, confined to a point or small area, which takes the form of small cavities.

Polarization: the change from the open-circuit electrode potential as the result of the passage of current.

Polarization curve: a plot of current density versus electrode potential for a specific electrode-electrolyte combination.

Pourbaix diagram (electrode potential-pH diagram): a graphical representation showing regions of thermodynamic stability of species in metal-water electrolyte systems.

Primary water stress corrosion cracking (PWSCC): SCC of nickel-base alloys in PWR environments.

Protection potential: the noblest potential where pitting and crevice corrosion will not propagate.

R

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Redox potential: the potential of a reversible oxidation-reduction electrode measured with respect to a reference electrode, corrected to the hydrogen electrode, in a given electrolyte.

Reduction: the gain of electrons by a constituent of a chemical reaction.

Reference electrode: a non-polarizable electrode with a known and highly reproducible potential.

Reversing DC potential drop (DCPD) technique: Highly accurate real-time crack growth rate measurement technique

Rust: a corrosion product consisting primarily of hydrated iron oxide. (A term properly applied only to ferrous alloys.)

S

Season cracking: An archaic term for stress-corrosion cracking (SCC) from the monsoon "season cracking" of brass cartridges in India.

Sensitization: precipitation of chromium carbides at the grain boundaries in austenitic stainless steel and nickel-base alloys that leads to a chromium depleted zone adjacent to the grain boundary.

Slow strain rate test (SSRT): an experimental technique for evaluating susceptibility to stress corrosion cracking. It involves pulling the specimen to failure in uniaxial tension at a controlled slow strain rate while the specimen is in the test environment and examining the specimen for evidence of stress corrosion cracking. Same as CERT.

Spinel: are any of a class of minerals/oxides of general formulation AB_2O_4 that crystallize in the cubic (isometric) crystal system, with the oxide anions arranged in a cubic close-packed lattice and the cations X and Y occupying some or all of the octahedral and tetrahedral sites in the lattice. X and Y can be divalent, trivalent or quadrivalent cations.

Standard electrode potential (SHE): the reversible potential for an electrode process when all products and reactions are at unit activity on a scale in which the potential for the standard hydrogen half-cell is zero.

Stress corrosion cracking (SCC): a cracking process that requires the simultaneous action of a susceptible alloy, corrosive environment and sustained tensile stress.

T

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Tafel slope: the slope of the straight line portion of a polarization curve, usually occurring at more than 50 mV from the open-circuit potential, when presented in a semi-logarithmic plot in terms of volts per logarithmic cycle of current density (commonly referred to as volts per decade).

Transgranular: through or across crystals or grains.

Transgranular stress corrosion cracking (TGSCC): SCC propagation through the grains as opposed to IGSCC, which is along the grain boundaries.

Transpassive region: the region of an anodic polarization curve, noble to and above the passive potential range, in which there is a significant increase in current density (increased metal dissolution) as the potential becomes more positive (noble).

Tuberculation: the process in which blister-like growths of metal oxides develop in pipes as a result of the corrosion of the pipe metal. Iron oxide tubercles often develop over pits in iron or steel pipe, and can seriously restrict the flow of water.

U

U-bend specimen: horseshoe-shaped test piece used to detect the susceptibility of a material to stress corrosion cracking.

V

Valence: a whole number (positive or negative) that represents the power of one element to combine with another. In general terms, the valence number represents the number of electrons in an atom or combined group of atoms that can be easily given up or accepted to react with or bond to another atom or group of atoms to form a molecule.

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